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Bioenvironmental Engineer's Guide to Indoor Air Quality Surveys



Emily C. Arceo

September 2014

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Chapter 1. Introduction

- a. Purpose: The purpose of this guide is to provide a basic process for base level Bioenvironmental Engineering (BE) technicians to complete typical indoor air quality (IAQ) surveys. The United States Air Force School of Aerospace Medicine (USAFSAM) created this document to simplify the IAQ survey process.
- b. Use: This guide has been developed as a companion document to AFRL-SA-WP-SR-2014-0012, *Technical Guide for Indoor Air Quality Surveys*, to provide the basic information a BE technician needs to perform a typical IAQ survey. To have a complete understanding of IAQ issues and their causes, the technician should be familiar with the contents of the *Technical Guide for Indoor Air Quality Surveys* before the survey process begins.

Chapter 2. Performing IAQ Surveys

- a. Notification: For BE, a typical IAQ survey may begin with a phone call or e-mail from building occupants who have complaints about the IAQ in their building, or it may begin by receiving an AF Form 190, *Occupational Illness/Injury Report* (AF 190), from Public Health. Once notification is received, it is up to BE to plan, organize, and execute an IAQ survey with assistance from appropriate agencies.
- b. Planning: The first step to completing an IAQ survey is to gather all relevant information. Depending on how BE is notified and how much information is initially given, this may begin with an occupant interview. The technician should contact the occupant(s) to gather information, such as the symptoms experienced and when/where the symptoms occur. For an example of an occupant interview, see Appendix A.

After completing the occupant interview, the technician should contact Civil Engineering (CE) to request assistance in conducting a building walkthrough and to inquire about any known issues in the building/area where the complaints occurred. For example, CE may be aware of contaminants in the ground under the building, or that the heating, ventilation, and air conditioning (HVAC) system is undergoing maintenance. Developing a positive working relationship with CE is vital to the success of an IAQ survey.

After gathering information from the occupant(s) and CE, the next step is to contact other stakeholders to invite them to participate in the building walkthrough. It is essential that the facility manager and CE participate, but PH and the Occupational Medicine physician should also be invited to attend. Scheduling conflicts may make it difficult for CE and BE to perform the building walkthrough together. In this situation, CE and BE may complete their portions of the walkthrough at separate times and reconvene afterwards to compare findings.

- c. Building Walkthrough: Walk through and around the building of interest while noting any conditions that may contribute to poor IAQ. This usually can identify the majority of IAQ problems. Using common sense and taking note of personal discomfort are vital to identifying problem areas. The first area to walk through should be the area where the majority of the symptoms have been experienced, followed by rooms adjacent to this area. Next, walk around

the perimeter of the building, and lastly, look at the HVAC system and the mechanical room where the HVAC system is located. It is important to inspect the HVAC system with a subject matter expert from CE. See Appendix B for a building walkthrough checklist.

d. Troubleshooting: If the walkthrough identified any concerning issues, they should be corrected as soon as possible. CE can create a work order to address most building-related deficiencies. See Appendix C for IAQ troubleshooting guidance.

e. Performing Basic Measurements: When the building walkthrough fails to uncover the IAQ concern, air quality indicators may help pinpoint problem areas. The most essential indicators are carbon dioxide (CO₂) concentration, relative humidity, and temperature. See Appendix D for basic measurement techniques.

f. Questionnaires: Questionnaires are not necessary in most cases, but they can provide additional information if a problem is not easily identifiable. BE should contact PH as far in advance as possible to discuss the distribution of questionnaires to building occupants. An example of a PH questionnaire is in the *Technical Guide for Indoor Air Quality Surveys*. If PH agrees, they will distribute the questionnaires and inform BE of the results. These results can further pinpoint symptom clusters and areas of concern within the building.

g. Results: Once BE determines the source of an IAQ concern and the stakeholders put a plan of action into place (i.e., CE creates a work order), BE should enter the results of the IAQ survey into the Defense Occupational and Environmental Health Readiness System (DOEHRS). Appendix E provides details on how to enter IAQ survey findings into DOEHRS.

h. Follow-Up: Contact the building occupant(s) and the facility manager in 30-60 days after corrective actions are implemented to ensure they were effective. If they were not effective, further investigation may be necessary.

i. Further Guidance: If the guidance in this document and in the *Technical Guide for Indoor Air Quality Surveys* is not sufficient to determine the source of an IAQ problem, contact the Environmental Safety and Occupational Health (ESOH) Service Center at USAFSAM for assistance. See Appendix F for a flow chart of the IAQ survey process.

Appendix A

Occupant Interview

This information is intended for interview purposes only (in person or over the telephone). It should not be used as a questionnaire or distributed to building occupants.

Questions to Ask May Include:

What symptoms/discomfort are you experiencing?

When did the symptoms/discomfort begin?

Have you sought medical attention for your symptoms?

Do the symptoms get worse? If so, when are they the worst?

Do they get better or lessen in intensity? If so, when are they the least intense?

Are you aware of any environmental sensitivities that you might have? For example: seasonal allergies or asthma.

Do you suspect that something particular is causing your symptoms? If so, what is it? Why do you feel this is causing your symptoms?

Which room(s) do you work in during a typical day?

How much time do you spend in each room?

What activities do you perform in each room?

Is there any further information you would like to add?

Appendix B
Building Walkthrough Checklists

Considerations to make during the walkthrough (This is not an all-inclusive list.)	Y/N		Notes (Location of issue, oddities, etc.)
Do you notice any comfort issues? (Smells, humidity extremes, temperature extremes, large temperature variances, etc.)	Y	N	
Are there any recognizable housekeeping issues? (Moldy food in breakrooms, visible dust, garbage accumulation, dead plants, etc.)	Y	N	
Are the walls and the ceiling free of water stains? If not, what caused the stain? Has the source been fixed? Is there visible mold growth?	Y	N	
Do any of the rooms appear to be visibly crowded? (As if too many people are located in one area)	Y	N	
Do all rooms have supply air vents?	Y	N	
Do all supply air vents deliver the designed airflow?	Y	N	
Are the supply and exhaust vents in rooms free of dust, dirt, and obstructions?	Y	N	
Are there mechanical dampers for the room supply vents? Are they open wide enough?	Y	N	
Are any chemicals stored near the complaint area? Review any safety data sheets for hazardous substances and ensure that they are stored correctly.	Y	N	
Are there pathways and pressure differences that could be moving contaminants into the complaint area from outdoors or other areas of the building?	Y	N	
Walk around the perimeter of the building, taking note of air intakes and any obvious pollution sources. Are the fresh air intakes located away from pollution sources? (Busy streets, loading docks, exhaust vents, garbage facilities, designated smoking areas, etc.)	Y	N	

HVAC Inspection (with CE)	Y/N		Notes (Location of issue, etc.)
Does the system currently meet the designed minimum outdoor airflow rate?	Y	N	
Are the fresh air dampers really open during normal operation?	Y	N	
Are the damper controls connected and functional?	Y	N	
Do the temperature controls work properly?	Y	N	
Is there a comprehensive maintenance schedule that is being performed?	Y	N	
Are cooling coils and drain pans cleaned regularly?	Y	N	
Are the air handling and fan-coil units easily accessible for inspection and preventive maintenance?	Y	N	
Is the HVAC system (including the cooling coils, ductwork, all plenums and chambers) reasonably free of dust, oil, and fibers?	Y	N	
Do the air filters have a minimum efficiency reporting value of no less than 6?	Y	N	
When were air filters replaced last? (provide date)			
Is the HVAC system free of standing water?	Y	N	
Are the drip pans under the cooling coils double sloped and made of a noncorrosive material?	Y	N	
Is the drip pan drain mounted and functioning in a manner that prevents water from accumulating in the pan?	Y	N	
Are the drip pans free of mold growth and evidence of past growth?	Y	N	
Are contaminants from the mechanical room (e.g., heater) exhausted so they cannot enter the air handler?	Y	N	
If the mechanical room acts as a return air plenum, is it free of trash, dirt, standing water, and chemical storage?	Y	N	
If insulation is used inside air handlers, is it fixed so fibers cannot enter the air handler? <i>Is it kept dry?</i>	Y	N	
Are the sections of the air handlers and ductwork that are expected to become wet during normal operation constructed of a material with cleanable surfaces?	Y	N	

Appendix C

IAQ Troubleshooting

The following tables can assist in pinpointing potential sources of issues based on symptoms, where symptoms occur, or when problems occur.

Table C-1. Potential Causes of IAQ Issues, Based on Complaints/Symptoms*

Complaints/Symptoms	Potential Cause		Comment
	Primary	Secondary	
Diagnosed infection or allergic disease	• Biological	• Low relative humidity	<ul style="list-style-type: none"> • Obtain information about potential causes from diagnosis. • Check for microbial contamination in room/area, ductwork, cooling tower, or at the air handler.
Swelling, itching, skin rash	<ul style="list-style-type: none"> • Biological (allergen) if small numbers affected • Chemical/particle if large numbers affected 	<ul style="list-style-type: none"> • Chemical/particle if large numbers affected • Biological if large numbers affected • Low relative humidity 	<ul style="list-style-type: none"> • Check for microbial contamination in room/area, ductwork, cooling tower, or at the air handler. • Check for fiberglass contamination from insulation in ducts or around building envelope. • Check for painting, adhesives, solvents, petroleum products used in maintenance or housekeeping.
Sinus headache	• Biological (allergen) e.g., pollen, mold	• Chemical /particle	<ul style="list-style-type: none"> • Could be allergen outside or inside. If outside, consider increasing filtration efficiency.
Wheezing, asthma	• Asthma triggers (pests, tobacco smoke, mold, ozone)	• None	<ul style="list-style-type: none"> • Check pest management procedures. • Ensure compliance with AFI 40-102, <i>Tobacco Use in the Air Force</i>. • Check for electronic air cleaners, which can produce ozone. • Check for mold.
Mild discomfort in eyes, nose, or throat Mild headaches General lethargy Generally not feeling well	<ul style="list-style-type: none"> • Lack of adequate make-up air • Temperature or humidity 	<ul style="list-style-type: none"> • Chemical/particle • Biological 	<ul style="list-style-type: none"> • Increase fresh air rate. • Monitor temperature and humidity. • Check for mold.
Odors	<ul style="list-style-type: none"> • Mold • Lack of adequate make-up air • Dirty coils/filters • Sewer gas, drain traps, sanitary vents 	<ul style="list-style-type: none"> • Leaky tanks, spills • Cleaning products, pesticides • Poor housekeeping practices • Fresh air intake located near contaminant source 	<ul style="list-style-type: none"> • Check for sewer line leak, septic tank leak, fuel tank leaks. • Ask about recent use of chemical products. • Check for particles burning on heat exchangers or hot radiators. • Check the location of the fresh air intake.
Legionnaire's disease	• Biological (Legionella)	• None	<ul style="list-style-type: none"> • Find source of aerosolized water (standing water in air handler, decorative fountain, etc.).

Table C-1. Potential Causes of IAQ Issues, Based on Complaints/Symptoms* (Concluded)

Complaints/Symptoms	Potential Cause		Comment
	Primary	Secondary	
Dry eyes, nose, or throat Sore throat Inability to wear contact lenses Headache Sinusitis Dusty	•Low relative humidity	•Particle	•Check humidity levels. •Look for dust/fibers in vents/air handlers.
Hot/cold spots Stuffy feeling Dusty	•Improper HVAC balance	•Negative pressure building	•Check for high CO ₂ levels. •Ensure fresh air dampers are open. •Ensure that the supply air fan is set to 5% greater than return fan.

*This table was adapted from the Environmental Protection Agency (EPA) IAQ Building Education and Assessment Model, dated 2008.

Table C-2. Potential Causes of IAQ Issues, Based on Where Symptoms Occur*

Symptoms	Potential Source Examples	Potential HVAC Problem Examples	Potential Pathway Examples
Localized to a specific area	•Kitchenette •Printers/copiers •Mold/moisture •Storage area •Local remodeling •Furniture/carpet •Fragrances/perfumes •Outdoor sources near air intake or window/door •Overcrowding in zone •Significant heat sources •Lack of housekeeping in the area	•Local exhaust •Local diffuser •Local thermostat •Local air supply •Contaminated local duct •Variable air volume (VAV) box malfunction •Problem in single zone HVAC system (contaminated filter, lack of outdoor air)	•Local HVAC duct •Source elsewhere in the building penetrating wall/floor or traveling up nearby stairwell/elevator •Hallway
Interior zone	•Source located in interior zone (copy room, mechanical room, storage closet, etc.)	•Interior zone getting less supply air and outdoor air than exterior zones because thermal loads are less	•None
Widespread	•Widespread remodeling/renovations •Building fabric/furnishings •General housekeeping •General building maintenance •General overcrowding •Significant heat sources •Outdoor source reaching all outdoor air intake vents, or vent of central air handler •Lack of make-up air	•Problems with a central HVAC system •Overall lack of HVAC maintenance •Maintenance activity performed on all air handlers	•Local source dispersed throughout building through central HVAC system

*This table was adapted from EPA's IAQ Building Education and Assessment Model, dated 2008.

Table C-3. Potential Causes of IAQ Issues, Based on When Problems Occur*

Pattern of Occurrence	Possible Causes
Mornings (may be more severe on Monday morning), then dissipates as day/week progresses	<ul style="list-style-type: none">•Failure to flush building at night and on weekends•Late startup of HVAC or late outdoor air damper openings during startup•Morning traffic pollution entering outdoor air vent
Latter part of the week	<ul style="list-style-type: none">•Occupants or their activities may be the source; possible inadequate outdoor air in HVAC to dilute pollutants
Recurrent on a particular schedule	<ul style="list-style-type: none">•Recurrent occupant/maintenance/housekeeping activity that takes place just prior to the symptoms•HVAC schedule/sequence related to symptom recurrence
Hot weather	<ul style="list-style-type: none">•Emissions from recently installed furnishings•Inadequate HVAC capacity•Economizer control malfunction
Mild temperatures	<ul style="list-style-type: none">•Economizer control malfunction•VAV system at part load delivering little supply air and little outdoor air

*This table was adapted from EPA's IAQ Building Education and Assessment Model, dated 2008.

Appendix D

Basic Measurement Techniques

Use a direct reading instrument to take measurements in several representative rooms for each air handler (both affected and unaffected rooms), as well as outside for comparison and in the return air plenum if possible [D-1]. The most essential are CO₂ concentration, relative humidity, and temperature. At least four direct readings per representative room are recommended for each comfort parameter. Spread the measurements throughout a day when the air handlers are in their usual operating mode. If there are two (or more) air handler modes, sample when the outside air is minimized and also when the fresh air dampers are open the widest [D-1]. This will ensure that fresh airflow is at acceptable levels in all VAV system operating modes. The facility manager or CE should be able to provide information about air handler modes. According to the EPA, “Readings should be made 3-6 feet off the floor, and at floor level, as persons suffering from cold feet may report that the room is too cold” [D-2]. Table D-1 provides the ideal ranges for comfort parameters in a building. Evaluate how CO₂ levels fluctuate throughout the day by placing a CO₂ meter with data logger in the return air plenum and in an affected area for 24 hours [D-1].

Table D-1. Ideal Ranges for Comfort Parameters

Parameter Measured	Ideal Ranges
Carbon Dioxide (CO ₂)	1000 parts per million (ppm) or less (although keep in mind that occupant symptoms tend to increase at levels higher than 600 ppm)
Relative Humidity	40% - 60%
Temperature	68°F - 76°F

Sampling for Specific Contaminants: Typically, IAQ problems can be solved without air sampling for specific contaminants; however, if this is necessary, refer to the *U.S. Air Force School of Aerospace Medicine Laboratory Sampling Guide* and contact the USAFSAM Laboratory Customer Service for assistance. It should be noted that **USAFSAM does not recommend performing sampling for mold.**

Smoke Tubes: Smoke tubes can be used to identify where air is entering and exiting a room, as well as how quickly the air is circulating. A few puffs of smoke near air vents, doors, or windows can show the direction of the airflow and any drafts or leaks that may be occurring [D-2].

References

- D-1. Bright PD, Mader MJ, Carpenter DR, Hermon-Cruz IZ. Guide for indoor air quality surveys. Brooks AFB, TX: Armstrong Laboratory, Occupational and Environmental Health Directorate; 1992 May. Technical Report AL-TR-1992-0016.
- D-2. Environmental Protection Agency. IAQ building education and assessment model (I-BEAM). 2008 Oct 21. Retrieved 1 March 2014 from http://www.epa.gov/iaq/largebldgs/i-beam/pdfs/text_modules_diagnosing.pdf.

Appendix E

DOEHRS Data Entry Requirements Guide

The way that an IAQ survey is documented in DOEHRS will depend on whether the survey was performed in an existing industrial workplace (that is, loaded as a shop in DOEHRS) or in a facility not related to an existing shop. To enter an IAQ survey that is specific to **an existing industrial hygiene (IH) shop in DOEHRS**:

1. Sign into DOEHRS.
2. Click on *Master Schedule* on the left side of the screen as shown in Figure E-1.

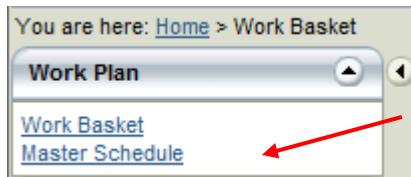


Figure E-1. Master Schedule

3. Click on *Add Master Schedule Task* as shown in Figure E-2.

A screenshot of the "Master Schedule - Search" page. It has a search form with fields for "Search" (dropdown set to "Shop"), "Task Type" (dropdown set to "All"), "Assigned Program Office Personnel" (dropdown set to "All"), "Between" (date range fields), and "Include Archived Records" (checkbox). At the bottom left, there are four links: "Add Master Schedule Task" (highlighted with a red arrow), "View WMP Tasks (IH Sampling Tasks)", "View EH Sampling Tasks", and "View Modeling Tasks".

Figure E-2. Add Master Schedule Task

4. In the *Task Type* dropdown menu, select *Indoor Air Quality Assessment* and click *Continue*.
5. Click on the magnifying glass icon next to *Shop* as shown in Figure E-3.

A screenshot of the "Schedule Information" form. It has two fields: "Shop*" and "Shop Priority". Next to the "Shop*" field is a magnifying glass icon. A red arrow points to this icon.

Figure E-3. Shop Magnifying Glass Icon

6. In the pop-up window, enter the shop name into the search field and click *Search*.
7. Select the correct shop and click *Add To Form*.

8. In the dropdown menu for *Task Frequency*, choose *One Time* as shown in Figure E-4.
9. Enter the date of the IAQ survey into the field titled *Projected Start Date* as shown in Figure E-4.

Master Schedule - Detail - Indoor Air Quality Assessment

* Indicates Required Field

Save Save and Begin Survey Cancel

Schedule Information			
Shop*	CAV Medical Treatment Fac.	POC/Contact Type	
Shop Priority	1	Skill Level	
Task Frequency*	One Time	Actual Start Date	
Projected Start Date*	2013/12/02 (yyyy/mm/dd)	Close Date	
Previous Close Date		External Due Date	
Projected Due Date	(yyyy/mm/dd)	Reason Task not Completed	
Required by Federal Standard	<input type="checkbox"/>		
Comments			

Figure E-4. Mandatory Fields

10. Click *Save and Begin Survey* (located on the bottom of the screen). The screen should now appear as shown in Figure E-5.

Indoor Air Quality Assessment

* Indicates Required Field

Shop Name: CAV Welding Other Actions -Indoor Air Quality Assessment-

Save Save And Continue Working Cancel

General Survey Information			
Shop	CAV Welding (FF2F8)	Shop Priority	High
Survey Date/Time*	2013/11/26 (yyyy/mm/dd) 1302 (1500)	Status*	In Progress
Detailed Evaluation/Follow-up			
Comments/Time Course of Events			
Contact Information			
Personnel Affected			
Location of Personnel (Room/Zone) Information			
Ventilation System Information			
Work Space Information			
Mechanical Room Information			
Major Mechanical Equipment Maintenance Information			
User Defined Questions			
Attachments (0)			
Program Office Information			

Save Save And Continue Working Cancel

Figure E-5. Indoor Air Quality Assessment

11. Enter the IAQ survey into the applicable sections in the screen on the preceding page. Findings of the survey that do not fit in provided sections may be added in *Attachments*.

Once surveys are entered and saved, they can be viewed by going to the *Shop Detail* page and clicking on *Indoor Air Quality Assessment* located in the *Surveys* folder for a particular shop (as shown in Figure E-6).

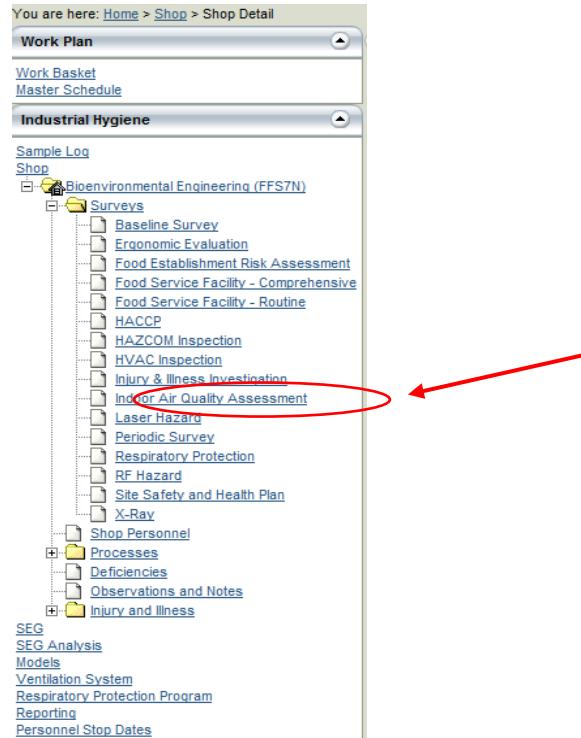


Figure E-6. Indoor Air Quality Assessment Link

Surveys Not Associated with Existing Shops in DOEHRS: Do **not** create an IH shop to add a shop survey form for IAQ. Instead, complete the IAQ survey report (e.g., memorandum for record) and attach all relevant files/documentation on the *Location Detail* page for the building. The attachments to building location records in DOEHRS can be thought of as an electronic version of a typical building folder. To enter an IAQ survey that is **not associated with an existing IH shop in DOEHRS**:

1. From the DOEHRS home screen, click on *Location* under the *Environmental Health* tab as shown in Figure E-7.

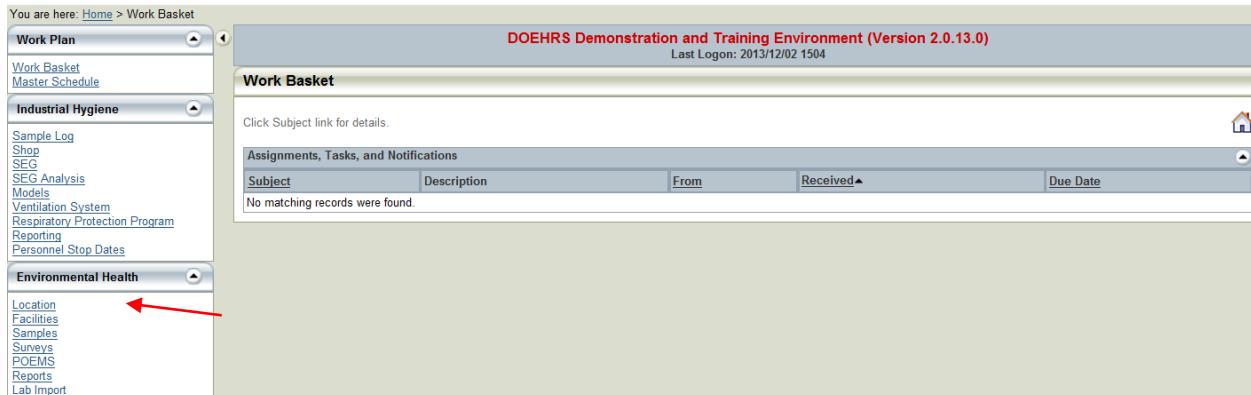


Figure E-7. Location

2. Click on *Browse By Location Tree* as shown in Figure E-8.

Figure E-8. Browse By Location Tree

3. If the building where the survey was performed is listed in the location tree, go to step 4. If the building is not listed in the location tree, skip ahead to step 5.
4. Click on the building in the location tree. This will take you to the *Location – Detail* page. Upload the IAQ survey documentation to the *Attachments* section of this page as shown in Figure E-9.

The screenshot shows the 'Location - Detail' page. At the top, there are buttons for 'Save', 'Save and Add Subordinate Location', 'Save and Add Shop', and 'Cancel'. To the right is an 'Other Actions' dropdown set to 'Locations'. Below these are sections for 'Location Properties' and 'Deployment Information'. A red arrow points to the 'Attachments (0)' section, which has a '+' button to add files. The bottom of the page has the same set of buttons as the top.

Figure E-9. Location – Detail

5. If the building was not in the location tree, it will need to be added. Go back to the *Locations – Search* page and click on *Add Location* as shown in Figure E-10.

The screenshot shows the 'Locations - Search' page. It includes search fields for 'Location Name' and 'Country', and date range fields for 'Start Date' and 'End Date'. There is also a checkbox for 'Include Archived Records' and a 'Search' button. A red arrow points to the 'Add Location' link at the bottom left of the page. Below the search area are links for 'Browse By Location Tree'.

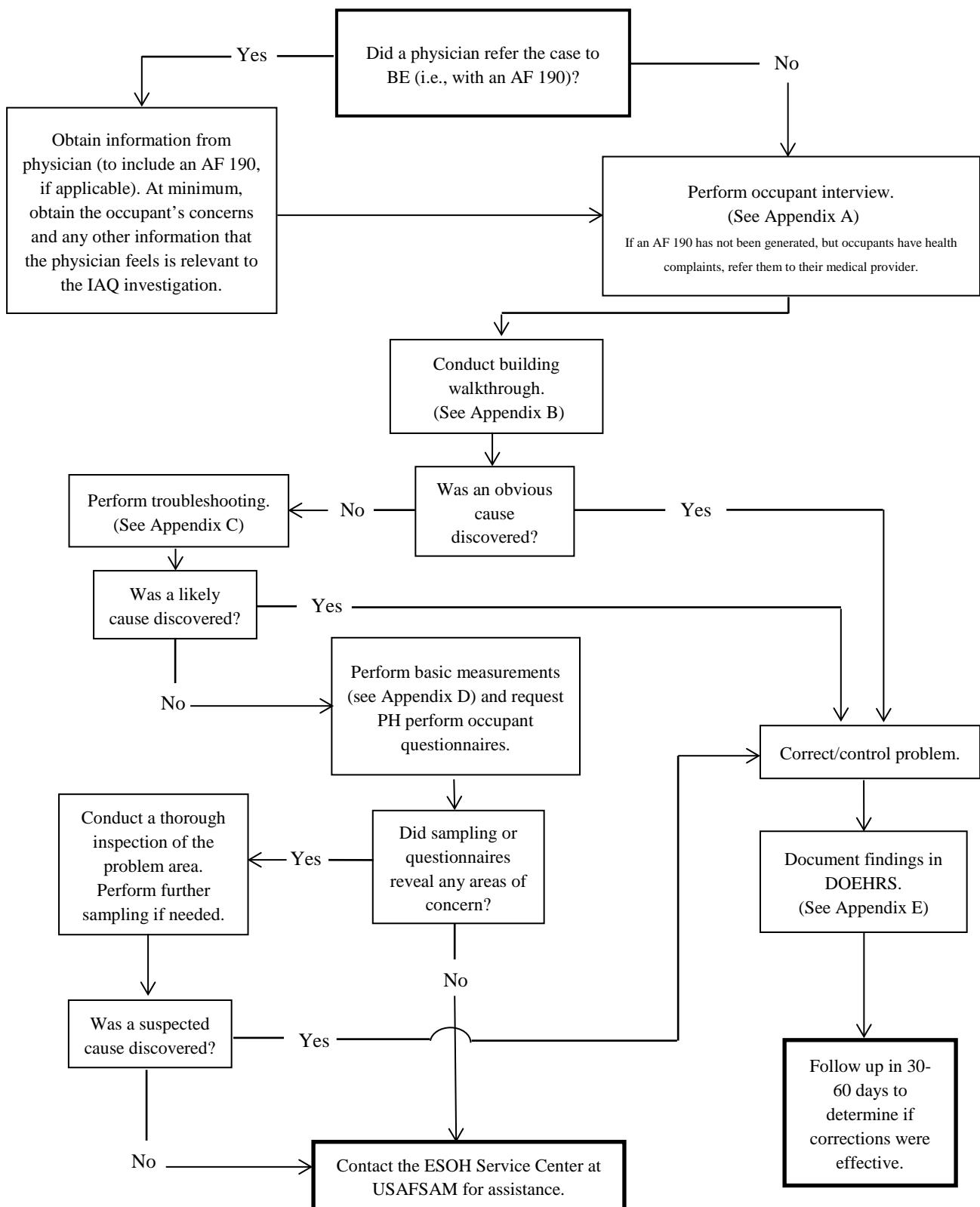
Figure E-10. Add Location

6. This will bring up the *Location – Detail* page as shown in Figure E-9. After filling in the required fields, click on *Save*. The IAQ survey documentation can now be uploaded to the *Attachments* section of this page.

See Chapter 7 of the DOEHRs Student Guide: *Location* for more information on creating and editing DOEHRs location records.

Appendix F

IAQ Survey Flowchart



LIST OF SYMBOLS AND ACRONYMS

BE	Bioenvironmental Engineering
CE	Civil Engineering
CO ₂	carbon dioxide
DOEHRS.....	Defense Occupational and Environmental Health Readiness System
EPA	Environmental Protection Agency
ESOH	environmental safety and occupational health
HVAC	heating, ventilating, and air conditioning
IAQ	indoor air quality
IH	industrial hygiene
PH	Public Health
ppm	parts per million
USAFSAM.....	United States Air Force School of Aerospace Medicine
VAV.....	variable air volume